EFFECT OF EXCLUDING SHREDDERS ON LEAF LITTER DECOMPOSITION IN TWO STREAMS

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ABSTRACT.—The effect of excluding shredders on leaf processing rates was studied in a Rocky Mountain stream in Utah and a cold desert stream in Washington. Experimentally excluding shredders significantly decreased the processing rate in both streams. Processing rates (k) were higher in the desert stream, and it is postulated that this is related to increased microbial activity due to the higher water temperatures.

The decomposition of allochthonous detritus in stream ecosystems has been shown to be a function of both physical, i.e., temperature and current, and biological, i.e., microbial and macroinvertebrate feeding, effects (Anderson and Sedell 1979). Macroinvertebrate shredders (Merritt and Cummins 1978), which feed directly on leaf litter in streams, have been estimated to account for 20% of total leaf decomposition (Cummins et al. 1973, Petersen and Cummins 1974, Cummins and Klug 1979). Although their role is still imperfectly understood, it is clear that coarse particle detritivores, or shredders, are extremely important members of some stream ecosystems. In the process of shredding leaves, they not only provide themselves with nutrients but convert coarse particulate organic matter (CPOM) to fine particulate organic matter (FPOM) and thus provide an energy source for fine particulate detritivores, or collectors (Cummins et al. 1973, Mackay and Kalff 1973, Cummins 1974, Iversen and Madsen 1977, Short and Maslin 1977, Cummins and Klug 1979). On the other hand, they may have an effect on species that use leaf packs as habitat or graze periphyton from the leaf surface.

The purpose of this paper is to document the importance of large shredders in the decomposition of leaves in two streams, a Rocky Mountain stream and a cold desert stream.

STUDY SITES

Stewart's Creek is a small second order (Strahler 1957) stream originating from a glacial cirque on Mt. Timpanogos about 33 km northeast of Provo, Utah County, Utah. The mean annual discharge is 0.25 m^3/s, and the annual water temperature ranges from 2.0 to 9.0 C. The stream gradient in the study section is 7%. Riparian vegetation in the study area consists of willow (*Salix* sp.), quaking aspen (*Populus tremuloides*), and box elder (*Acer negundo*). For a more detailed description of the stream, see Sakaguchi (1978) and Oberndorfer et al. (1984).

Rattlesnake Springs is a first order, permanent, spring-fed stream about 43 km northwest of Richland, Benton County, Washington. It originates as seeps and is fed by one major spring, resulting in a base flow of ca 0.01 m^3/s. Mean annual precipitation in the region is ca 14 cm, and the stream water temperature varies bewteen 2.0 and 22.0 C. Rattlesnake Springs is in the shrub-steppe desert in the northerly extension of the cold-desert physiographic province. For further information, see Cushing et al. (1980), Cushing and Wol (1982, 1984).

METHODS

STEWART'S CREEK.—In the fall of 1978, 12(leaf packs were constructed using three gram (dry wt) of box elder leaves. The packs were fastened to lids of one-pint plastic freezer con tainers as described in Merritt et al. (1979) The freezer containers had all four sides an bottoms cut out. Half (60) of the container were left open on all sides (control), and hal were covered with 1 mm Nitex (shredder ex clusion). For a complete description of th

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TABLE 1. The effect of excluding shredders on (A) mean percent of original leaf material remaining and the rate of decomposition (k) of leaf material in Stewart's Creek, Utah, and (B) the number of shredders, total organisms, and collectors per gram DW leaf material. Numbers are treatment means; means connected by solid line are not significantly different at $\alpha = 0.05$. SX = shredder exclusion, C = control.

A. Percent of leaf material remaining

Treatment	Week 0	4	8	12	16	20	k
Shredder exclusion (fine mesh)	100	64	42	18	16	10	−0.0166
Control	100	53	18	6	5	4	−0.0269

B.

Dependent variable		
Shredders	93 (SX)	88 (C)
Total organisms	1139 (C)	430 (SX)
Collectors	1030 (C)	330 (SX)

cages, see Merritt et al. (1979). Leaf packs were randomly assigned to an experimental treatment, placed in the containers, and randomly assigned to transects in the stream. Each treatment was represented in each transect, although the position of the treatment within the transect was determined randomly. The cages were placed over the packs at the beginning of the experiment. Two packs from each of the treatments were removed from the stream according to the following schedule: two packs per treatment per week for two consecutive weeks and four packs per treatment on the third week, for a total of 21 weeks. Four packs were removed every three weeks to give a better estimate of invertebrate numbers. The packs were brought back to the laboratory, where the macroinvertebrates were washed from the leaves. Leaves were dried at 50 C for 48 hr and weighed. Macroinvertebrates were preserved in 70% ethanol and later sorted to lowest taxon possible and counted. The interoccular distance of all *Zapada cinctipes* (Plecoptera: Nemouridae) were measured to determine size distributions. The dates for this experiment were from 14 November 1977 to 7 February 1978.

RATTLESNAKE SPRINGS.—Methods used on Rattlesnake Springs were identical to those described above except that 27 exclusion and 27 control leaf packs were used. This experiment ran for nine weeks, with three leaf packs per treatment removed weekly. No cages were placed over the control packs. The dates for this experiment were from 2 August 1978 to 9 October 1978.

METHODS OF ANALYSIS.—A negative exponential model was used to describe leaf pack processing (e.g., Petersen and Cummins 1974). The effects of treatments on the processing rate coefficients (k) were analyzed, with analysis of covariance using linear contrasts to test for homogeneity of slopes (Hanson 1978).

RESULTS AND DISCUSSION

STEWART'S CREEK, UTAH.—The effects of the experimental treatments on the rates of leaf litter processing are shown in Table 1A. The shredder exclusion treatment (fine mesh) had more leaf material remaining on all dates of the study than the control treatment. There was significant difference ($p < 0.001$) between the shredder exclusion treatment ($k = -0.0166$) and the rates of the control ($k = -0.0269$).

The fine meshed cages (shredder exclusion) were designed and constructed to exclude the larger instars of the dominant shredder, *Zapada cinctipes*, from leaf packs. Smaller *Z. cinctipes* instars were able to pass through the 1 mm mesh screen and colonize the leaf packs within the exclusion cages. Although the control and the shredder exclusion packs had significantly different processing rates, they did not differ in the number of shredders (*Z. cinctipes*) per gram dry weight of leaf material when averaged over the entire sampling period, although the effect of absolute numbers was not tested. The difference in processing rates was probably due to the fact that only smaller *Zapada* were allowed in the exclusion cages, whereas all sizes were found in the control cages. It would appear from these data that not only is the number of shredders im-

TABLE 2. The effect of excluding shredders on (A) mean percent of original leaf material remaining and the rate of decomposition (k) of leaf material in Rattlesnake Springs, Washington, and (B) the number of shredders and total organisms per gram DW leaf material. Numbers are treatment means; means connected by solid line are not significantly different at $\alpha = 0.05$. SX = shredder exclusion, C = control.

A. Percent of leaf material remaining

Treatment	Week 0	2	4	6	8	k
Shredder exclusion (fine mesh)	100	65	41	25	16	−0.0213
Control	100	48	23	12	6	−0.0417

B.

Dependent variable		
Shredders	2.5 (SX)	4.8 (C)
Total organisms	77 (SX)	145 (C)

portant in determining the processing rate but that the size of the shredder is also an important factor to consider. There was a difference between the leaf weight loss rate in the controls and the shredder exclusion treatments, especially between weeks 4 and 8, although there was no difference in the number of shredders (Table 1B).

The dominant functional feeding group in all treatments was the collector-gatherer group (Table 1B). There were significantly fewer collector-gatherers in the shredder exclusion treatment. This was probably due to the exclusionary function of the fine mesh used on the cages in this treatment and/or a response to reduced shredding in the early portion of the experiment.

RATTLESNAKE SPRINGS, WASHINGTON.—Exclusion of shredders in the leaf packs of the cold desert stream results in a significantly lower processing rate (Table 2A). Both the k value for the control packs (k = −0.0417) and the experimental packs (k = −0.213) were higher than their counterparts in Stewart's Creek. Since the major shredders in Rattlesnake Springs were amphipods and essentially excluded from the exclusion packs, it is believed that the higher k rates in the cold desert stream were probably due to increased microbial processing (Reice and Herbst 1982). Short et al. (1984) found higher processing rates of *Salix nigra* leaves in the warmer of two Texas streams, and Suberkropp et al. (1975) and Kaushik and Hynes (1968) documented the positive relation between increased rates of leaf decomposition and increased water temperatures. The water temperature in Rattlesnake Springs during the experiments was 20–22 C. At these temperatures we would expect microbial processing to dominate the system.

Approximately 50% of the control leaf material was processed during each two-week period (Table 2A). There was no significant difference between either the number of shredders per gram dry weight leaf material or the total number of organisms in the control and experimental packs (Table 2B).

CONCLUSIONS

The processing of leaf litter is mediated by a array of biological and physical factors. By ex cluding shredders in a Rocky Mountain and col desert stream, significantly faster processin rates were found in the leaf packs exposed t shredder processing. Furthermore, the process ing rates in both control and exclusion packs i the cold desert stream were higher than thei counterparts in the Rocky Mountain stream. W attribute this partly to the type of shredder present in the desert stream but more likely t the higher mean water temperature during th experimental period, which probably increase microbial processing.

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